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The importance of camel milk and its dairy products – a review

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ABSTRACT

Camel milk and dairy products based on camel milk are consumed by people in various countries, particularly Asia and Africa. Traditionally, products based on camel milk products have been an essential source of protein for people living in arid countries of the world. Here, we have discussed the chemical composition of camel milk and the technological features and limitations in the production of dairy products from camel milk. Moreover, different species or strains of LAB such as *Lactobacillus plantarum, Lactobacillus fermentum, Lactobacillus casei, Enterococcus faecium, Streptococcus thermophilus, Weissella confusa* were detected as the prevalent bacteria in camel milk and camel milk products. Although camel milk has been subjected to numerous studies, technical analyses on an industrial scale remain scarce, especially for processed camel milk products. Further comprehensive research is needed to improve the quality of camel milk dairy products so that they can compete with milk from other livestock.

Keywords: camel milk composition, dairy products, shubat, LAB, review

INTRODUCTION

For thousands of years, the camel has been used by humans as a means of transportation and goods. However, it is unfair to think this way about this animal because camels greatly support people in arid areas, giving their milk to satisfy hunger and thirst **[1]**. Camel breeding is developed in the desert and semi-desert zones in African, Arab, and Central Asian countries and Mongolia **[2]**. Camels are markedly superior to other farm animal species in resilience to extreme desert conditions **[3]**. Camel breeding in Kazakhstan is also a traditional branch of livestock breeding. Currently, Kazakhstan is experiencing an increase in the number of camels (both one-humped and two-humped camels and hybrids). Moreover, camel breeding in Kazakhstan is developing in Mangyshlak, Kyzylorda, and South Kazakhstan regions **[4]**. The genus Camelus includes three species of camels, of which there are two (*C. dromedarius* and *C. bactrianus*) in Kazakhstan. *Dromedaries* have one, and Bactrians have two humps, and they are resistant to harsh climatic conditions of deserts and semi-desert zones **[5]**.

In the global community, cow's milk produces fermented milk products. However, it contains casein, which clogs blood vessels. Daily consumption of cow's milk in some people due to intolerance to this product destroys pancreatic cells and worsens carbohydrate metabolism, which leads to diabetes mellitus. Camel milk (CM) is very nutritious and completely secure for consumption **[6]**, **[7]**. Recently, diabetes mellitus has been increasing all over the world **[8]**. Camel milk is albuminous in its physical and chemical parameters and is considered the closest to mother's milk **[9]**. Although the demand for dairy products made from camel milk is growing every day, the camel milk dairy industry needs to pay more attention to its resources. This article discusses the general composition of camel milk, in particular, an overview of isolated LAB strains in camel milk and camel milk products, and the possibility of using camel milk to produce food products.

Figure 1 Fresh camel milking. Camels are being bred for the first time in the Bukhar-Zhyrau district of the Karagandy Region and now local residents produce their own shubat, a fermented camel milk beverage. Even though the main camel breeding regions in Kazakhstan are usually in the south and west parts of the country, the Karagandy Region is located in the central part of Kazakhstan. Kazakh Bactrian and single-humped dromedary camels produce milk with 4 percent fat or more. (Source: **[137]**).

Camel milk composition

Camel milk has a white, sweet, or sweet-salty taste, thick consistency, and foams strongly when poured. Camel milk varies considerably from cow's milk in physical and chemical parameters. A meta-analysis conducted on camel milk reported a fat content of 3.82%, total protein of 3.35%, lactose of 4.46%, dry matter of 12.47%, and ash of 0.79% **[10]**. The caloric value of CM was found to be about 61 Kcal/100 mL, while *C. bactrianus* showed a much higher value of 82.70 Kcal/100 mL **[11]**. The protein content in camel milk varies between 2.9% to 4.9%, consisting mainly of two types: caseins and whey proteins. The fat content ranges from 1.2% to 6.4%, characterized by a higher proportion of long-chain fatty acids and a notable amount of linoleic acid and unsaturated fatty acids, essential for nutrition. Camel milk is also relatively rich in lactose, with an average of 4.4%. One of the distinguishing features of camel milk is its high vitamin content, including fat-soluble vitamins (A, E, D) and water-soluble vitamins (B, and particularly vitamin C). This makes it an excellent source of essential nutrients. Additionally, camel milk is rich in minerals, particularly calcium and potassium, vital for various bodily functions. Overall, the average composition of camel milk includes 3.1% protein, 3.5% fat, 4.4% lactose, 0.79% ash, and 11.9% total solids. The milk's low content of short-chain fatty acids and its rich profile of vitamins and minerals make it a highly nutritious option, suitable for various dietary needs **[136]**.

Proteins

Milk proteins are high molecular weight elements comprising amino acids linked by peptide bonds. According to the literature, the total protein content per 100 g in raw camel milk ranges between 2.15-4.9%, with an average of 3%, while the amount of casein varies between 50-87%, and whey is 20-25% of the total protein **[12]**, **[13]**, **[14]**. Proteins in milk are divided into caseins and whey proteins. Casein belongs to complex proteins and is found in milk as granules, formed with the participation of calcium ions, phosphorus ions, and others **[15]**. Casein contains four main fractions: α_{S1}-, α_{S2}-, β-, and k-casein. Scientists have found that the main protein allergens of cow's milk proteins are considered to be the presence of β-lactoglobulin (as well as in the milk of other ruminants) **[16]**. Under the action of acids, enzymes, and acid salts, casein coagulates and precipitates, which is used in cheese production, etc. **[17]**. After casein removal, soluble whey proteins remain in milk whey, the main ones being λ-lactalbumin, β-lactoglobulin, lactoferrin, lysozyme, immunoglobulins (IgG), which belong to blood plasma proteins **[18]**. The protein concentrations in camel milk ranges as follows: α_S-casein (21%), β-casein (65%), and κ-casein (3.5%) of the total casein **[19]**. According to several authors, the fraction of α_{S1}-casein fraction is much lower than in other livestock's milk, and β-lactoglobulin is almost absent **[20]**, **[21]**, which is of interest in studying the allergenicity of camel milk and dairy products **[22]**. Protein of camel milk is dominated by immunoglobulin and lactoferrin, which have therapeutic, antioxidant, and immunostimulant properties that protect the human body **[23]**, **[24]**. Konuspayeva et al. detected the mean values of IgG of 0.718 ±0.330 mg/mL in Kazakhstan camel milk. The authors also indicated seasonal variations in IgG concentrations, with higher values observed in winter **[25]**. IgG changes were also detected at different milking times (11.8-211.1 mg/mL) **[26]**. Lactoferrin in camel milk samples varies from 0.02-7.2 mg/mL **[27]**, **[28]**, and it was found to be higher in colostrum **[29]**. It also said that camel milk contains more lactoferrin than bovine milk **[30]**, **[31]**. The biological and nutritional value of proteins is determined by the amino acid composition, especially the essential amino acids. It has been studied that camel milk proteins are richer than other animals' milk proteins in essential amino acids such as lysine, phenylalanine, threonine, etc. **[32]**. According to studies, around 17-18 amino acids were detected in camel milk **[4]**, **[33]**. They are essential for vital processes such as building proteins and synthesizing hormones and neurotransmitters.

Vitamins and minerals

Vitamins are low molecular weight organic compounds, which, present in food in small amounts, are essential components that regulate metabolism. Studies showed camel milk contains more vitamin C and niacin (PP) **[34]**, **[35]**, **[36]**. The amount of vitamin C in camel milk samples from different areas of Xinjiang province ranges between 12.10-41.25 µg/mL **[37]**. It is believed that the amount of vitamin C in camel milk depends on the diet and individual characteristics of the animal. Notably, Konuspaeva et al. reported variability in vitamin C content by region and season **[38]**. The relatively high amount of vitamin C in camel milk results from eating important nutrients in an arid area where fruits and vegetables are deficient in vitamin C. However, compared to cow's milk, camel milk has a small amount of A, E, B1, B2-, B9, and B5 vitamins **[39]**. Minerals are metal ions and inorganic and organic acid salts of milk. Camel milk and shubat are superior to cow's milk in micronutrient content, especially iron and copper **[40]**, **[41]**. Faye and Beugoumi reported variations in camel milk copper (30-800 µg/100 mL) and calcium (0.27-2.57 µg/100 mL) **[42]**.

Lipids

The nutritive importance of food products especially milk is assessed by the amount and composition of milk fat lipids, the content of unsaturated fatty acids, which play an important role in metabolism. Camel milk has much less cholesterol and fat and is a great source of unsaturated fatty acids **[43]**, **[44]**. The fat content of camel milk is only 1.2-4.5% **[45]**. However, a study of camel milk in different regions of Xinjiang (China) shows that the fat content of camel milk can be as high as 7.02% **[37]**. According to the research of Rafiq et al. **[33]** and Konuspayeva et al. **[43]** a high content of saturated fatty acids was found in Mongolian and Kazakh camel milk samples, respectively. In a previous study, camel milk contained higher levels of n-3 PUFAs compared to other livestock and was considered a functional food for the human diet **[46]**. In addition, the difference in lipid composition can be explained mainly by the different feeding conditions and camel breeds **[47]**. It has been demonstrated that camel milk from East Africa contained more fat than samples from Western Asia **[10]**. Also, seasonal variations influence most alterations in the compounds of camel milk **[48]**.

Camel farming

Camel breeding is a branch of animal husbandry engaged in the breeding and utilization of camels. It is developed in the zone of deserts, semi-deserts, and dry steppes. In Africa, the Middle East, Uzbekistan, Tajikistan, India, Pakistan, and Afghanistan breed *Dromedaries*; Kazakhstan, Kyrgyzstan, Mongolia, and China breed *Bactrians*. In every country where camels are raised, camel milk is consumed. As a dairy animal, the camel has the advantage of a long lactation period and the ability to be used for many years. It is difficult to determine the milk production of camels, as they are milked with a camel calf that has time to suck most of the milk. Dairy productivity also depends on the age of the animal **[49]**. For instance, low milk yields were observed in the first and ninth parties **[50]**. Interestingly, camel calving from November to February had higher peak milk yield and longer lactation periods **[51]**. According to Faye, camel milk production ranges from 1,000 to 12,000 liters per lactation, and the lactation period varies between 9-18 months **[52]**. Moreover, the mean daily milk yield was 8.17 L in Pakistan **[53]**. Overall, it was found that the daily milk yield of the camelid ranges from 3.5 to 40 litres **[54]**. Figure 1 shows the process of camel milking in the Karaganda region of Kazakhstan.

Raw camel milk and microbiological safety

Camel milk and dairy products based on camel milk are consumed by people in various countries, particularly, in Asia, and Africa. However, the consumption of unpasteurized raw camel milk from family farms still continues in some places worldwide. The most important characteristics of dairy products are their safety and microbiological stability. Raw camel milk may be contaminated with various pathogenic bacteria from many sources (udder, equipment, environment, etc.). Somatic cells are cells of various tissues and organs that are part of the tissues of the milk passages involved in milk secretion and milk excretion. In the udder, there is a constant renewal of epithelial tissue cells. The presence of a certain level of somatic cells in milk is natural. Still, an elevated level of somatic cells indicates that there are issues, primarily mastitis, in the dairy herd, the symptoms of which will manifest significantly later. In camel milk, somatic cell count (SCC) levels are not yet determined. It was recommended that 150 x 10^3 SCC cells/ml is a threshold value for healthy camel milk **[55]**. Furthermore, *Staphylococcus aureus* and *Salmonella* were detected in raw milk samples in Saudi Arabia **[56]**, **[57]**. Notably, Garcell et al. reported the Brucellosis outbreak related to camel milk consumption **[58]**. In addition, tetracycline and oxytetracycline residues were found in some cow and camel milk samples **[59]**. Overall, camel health, milking procedures, environment storage, and transport conditions can affect the microbial contamination of camel raw milk. Therefore, it is important to test raw camel milk and its processed product samples for microbiological quality before use **[60]**.

Pasteurizated camel milk

Pasteurization is one of the mandatory steps in the industrial production of milk and other products. The pasteurization of camel milk is complicated by the fact that it is impossible to maintain the temperature. Konuspayeva et al. reported that no standards for pasteurization conditions have been developed for camel milk **[61]**. In addition, alkaline phosphatase (ALP), the main marker of pasteurisation, is immediately negative after heat treatment. However, the amount and activity of ALP varies between animal species and cannot be applied to non-bovine milk. Moreover, it is well-known that pasteurization influences the quality of milk and its products. For instance, Elyas revealed that low fat and protein levels in fermented camel milk after pasteurization compared to un-pasteurized one **[62]**. Another study showed that low-temperature long-time pasteurization did not influence casein micelles size in camel milk. At the same time, high-temperature short-time, ultra-high temperature, and high-pressure treatment (HPP) caused decreases in particle size. Besides, HPP treatment kept a higher amount of bacteria **[63]**. Therefore, there is a need to develop standardized pasteurization conditions that can be applied to camel milk.

Fermented camel milk

It has been proven that camel milk and fermented products based on it have a high nutritional value and biomedical properties, which makes them a significant foodstuff **[64]**. Lactic acid bacteria (LAB) are widely used in many biotechnological and food industries – in the production of fermented milk products, enrichment of various foods, and creation of probiotics and dietary supplements **[65]**. Food products enriched with probiotic cultures have also been popular in the last decade. Scholars from different countries have noted that bacteria of the genera *Lactobacillus, Enterococcus, and Bifidobacterium* are the most commonly used bacteria in the food and biotechnology industries as probiotic cultures **[66]**. Raw camel milk and spontaneously fermented dairy products may be considered as sources of potential probiotics. Sourdough cultures specifically designed for camel milk fermentation could be an important step toward better utilization of camel milk. The Table 1 shows the different species, such as *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Lactobacillus casei*, *Enterococcus faecium*, etc., which were identified as the predominant bacteria in camel milk and camel milk products.

Table 2 LAB species isolated from camel milk and products across the globe.

Product type	*Species/strains*	Countries	Sources
Raw camel milk	*Enterococcus faecium* *Lactococcus lactis* *Pediococcus pentosaceus* *Pediococcus acidilactici* *Weissella confusa* *Leuconostoc pseudomesenteroides* *Lactobacillus reuteri*	Kuwait	**[67]**
	Lactococcus lactis *Enterococcus lactis* *Lactobacillus plantarum*	India	**[68]**
	Lactobacillus fermentum *Pediococcus acidilactici* *Pediococcus pentosaceus* *Weissella confusa* *Lactobacillus rhamnosus* *Lactobacillus plantarum* *Lactobacillus brevis*	Kazakhstan	**[69]**
Fermented milk	*Lactobacillus oryzae* *Lactobacillus casei* *Lactobacillus paracasei* *Lactobacillus curizae* *Lactobacillus plantarum* *Enterococcus lactis* *Pediococcus pentosaceu* *Pediococcus acidilactici* *Enterococcus faecium* *Weissella confusa*	Kazakhstan	**[69]**
Raw camel milk	*Lactococcus lactis* subsp. *lactis* *Lactobacillus helveticus* *Streptococcus salivarius* subsp. *thermophilus* *Lactobacillus casei* subsp. *casei* *Lactobacillus plantarum*	Morocco	**[70]**
	Streptococcus thermophilus *Leuconostoc mesenteroides.* *Lactobacillus helveticus,* *Lactococcus lactis*	Inner Mongolia	**[71]**
Raw camel milk	*Enterococcus faecium BagHom4* *Streptococcus equinus Omer9*	Saudi Arabia	**[72]**
Stirred yogurt (Laban) made from camel milk	*Streptococcus equinus Anwr4* *Streptococcus equinus Zaki1* *Streptococcus equinus Salam7*	Saudi Arabia	**[72]**

Table 2 Cont.

Product type	*Species/strains*	Countries	Sources
Raw camel milk	*Enterococcus bulliens sp. nov.* *Enterococcus sulfureus ATCC 49903(T)* *Enterococcus italicus DSM 15952(T)* *E. sulfureus LMG 13084(T)*	Morocco	**[73]**
Shubat	*Lactobacillus helveticus* *Lactobacillus kefiranofacien* *Streptococcus salivarius*	Mongolia, Inner Mongolia	**[74]**
Raw camel milk	*Leuconostoc mesenteroides* *Lactobacillus casei* *Weissella cibaria* *Pediococcus pentosaceus* *Enterococcus durans* *Enterococcus faecium* *Enterococcus lactis*	Iran	**[75]**
	Lactococcus lactiis *Lactobacillus plantarum* *Lactobacillus paracasei* *Enterococcus spp.* *Lactobacillus spp.* *Lactococcus spp.* *Lactobacillus brevis*	Morocco	**[76]**
	Leuconostoc mesenteroides *Lactobacillus plantarum* *Weissella paramesenteroides* *Weissella confuse*	Iran	**[77]**
	Lactococcus garvieae C47	United Arab Emirates	**[78]**
Raw camel milk	*Lactococcus* *Enterococcus* *Streptococcus* *Leuconostoc*	Morocco	**[79]**
Raw and fermented camel milk	*Lactobacillus*	Saudi Arabia (Makkah area) Egypt (Fayoum	**[80]**
Shubat	*Lactobacillus plantarum* *Lactobacillus casei* *Lactobacillus helveticus* *Lactococcus lactis* *Lactobacillus paracasei spp. paracasei*	Kazakhstan	**[81]**
Tarag	*L. delbrueckii ssp. bulgaricus* *L. helveticus* *L. delbrueckii ssp. lactis* *L. fermentum* *Lactococcus lactis ssp. lactis.*	Mongolia	**[82]**
Fermented camel milk	*Lactobacillus paracasei subsp. paracasei*	Mongolia	**[83]**
Raw camel milk	*Weissella confusa* *Weissella cibaria* *Enterococcus durans*	Morocco	**[84]**
Ethiopian traditional fermented camel milk	*Streptococcus* *Lactococcus* *Weissella*	Ethiopia	**[85]**

Table 2 Cont.

Product type	*SPECIES/STRAINS*	Countries	Sources
Raw camel milk	*Limosilactobacillus reuteri strain 2892*	Iran	**[86]**
	Enterococcus faecium	Iran	**[87]**
	L. mesenteroides	Algeria	**[88]**
	L. brevis	Algeria	**[89]**
	Lactiplantibacillus plantarum LC38	TUNISIA	**[90]**
	Lactococcus lactis KX881768 *Lactobacillus plantarum KX881772* *Lactococcus lactis KX881782* *Lactobacillus plantarum KX881779*	Abu Dhabi, UAE	**[91]**
	Lactococcus lactis SCC133 and SLch14	Tunisia	**[92]**
	Lactobacillu *Lactococcus* *Streptococcus* *Enterococcus*	Ethiopia	**[93]**
Spontaneously fermented camel milk	*Lactococcus lactis* *Lactobacillus plantarum* *Pediococcus acidilactici*	Ethiopia	**[94]**
Chal	*L. plantarum* *L. paraplantarum* *L. kefiri* *L. gasseri* *L. paracasei,* *Leuconostoc (Leu.) lactis* *Weissella (W.) cibaria* *Enterococcus (E.) faecium*	Iran	**[95]**
Raw and fermented camel milk (Suusac)	*S. thermophilus* *Lc. lactis subsp. lactis* *S. infantarius subsp. infantarius*	Kenya	**[96]**
Gariss	*Lactobacillus plantarum* *Lactococcus raffinolactis*	Sudan	**[97]**
Raw camel milk	*Leuconostoc mesenteroides subsp. dextranicum* *Lactococcus lactis subsp. lactis* *Lb. plantarum* *Lactobacillus brevis*	Algeria	**[98]**
"Shmen", a traditional butter made from camel milk	*Lactobacillus plantarum* *Lactobacillus delbrueckii ssp. bulgaricus* *Lactococcus lactis ssp. lactis biovar diacetylacti* *Lactococcus lactis ssp. cremoris* *Leuconostoc pseudomesenteroides* *Lactobacillus paracasei ssp. paracasei* *Leuconostoc gelidum* *Enterococcus faecium*	Algeria	**[99]**

Sour milk products have been known since antiquity. Depending on climate and lifestyle, each region has its national product. They have in common that they are obtained by fermenting milk from different animals. *Shubat* is a lactic acid beverage produced from natural camel milk due to lactic acid and alcoholic fermentation. It is also called as "*Khoormog*" in Mongolia or "*Chal*" in Iran **[100]**. It has quiet specific taste and smell. There is a distinction between ready Shubat by aging: one-day aging – young, two-day aging – medium strength, and three-day aging – strong. The best is a drink of 2-3 days of aging. During fermentation, *Shubat* density, dry residue, and milk sugar content decrease, lactic acid level, and acidity increase, resulting in the synthesis of ethyl alcohol and carbon dioxide. The the high content of vitamin C is preserved **[101]**. The previous study showed that some PUFAs were detected only in Shubat. Besides, the concentration of some amino acids, including threonine, aspargine, alanine increased compared to raw milk and milk powder **[4]**. The pH values in *Shubat* were between 3.7-4.1 **[102]**. Manaer et al. reported the effect of shut in type-2 diabetic rats. Furthermore, the authors speculated that its probiotic function may increase the function of β-cells **[103]**. Shubat has also been successfully used to treat tuberculosis **[104]**.

In addition, spontaneous fermentation has created many traditional products such as *Gariss* in Sudan, Laben in Arab countries, and *Suusac* in Kenya. Sulieman et al. (2022) reported that *Gariss* contains 3.4-3.85% protein, 2.2-2.9% fat, 1.3-1.4% lactose, 0.75-0.8% ash, 1.35-1.4% ethanol, 1-1.8% acidity **[105]**. Furthermore, forty-five strains of LAB were detected in *Suusac*, with *L. mesenteroides* and *L. plantarum* predominating **[106]**. A comparative study of *Gariss*, *Suusac*, and *Shubat* revealed that they had 2.8-5%, 4%, and 4.3% fat; *Gariss* and *Suusac* had 2.3-3.4% and 3% protein; *Gariss* and *Shubat* had 0.51-1.3% and 0.75% ash, respectively **[107]**. However, very few studies have been published on the chemical composition and medicinal properties of shubat or other traditionally fermented camel milk products.

Camel milk cheese

Today, an important direction is the creation of new types of products with functional properties, high quality, and biological value based on the use of local sources of raw materials with a specific chemical composition. Coagulation of milk proteins is an important part of the technological production process of most dairy products. In industrial production conditions, controlling and regulating technological parameters during milk coagulation remains important. Camel milk is rarely used to make cheese because of the thickening problem **[108]**. The basic principle of cheese making is to thicken the milk to form curds and whey. The difficulty in obtaining cheese from camel milk alone is because casein, which plays a determining role in the rennet curdling of milk, has a different primary structure than casein in cow milk. According to current theory, the enzyme chymosin in casein cleaves the peptide bond between phenylalanine-105-methionine 106, broken 200 times faster than other peptide bonds. Camel milk does not curdle well, forming a loose and delicate clot that escapes the whey **[109]**.

Current cheese-making methods speed up this process, thanks to the involvement of rennet (bacteria that produce lactic acid). Ramet studied that camel milk can be coagulated by adding calcium phosphate and vegetable rennet **[110]**. Al-Zoreky et al. used recombinant camel chymosin to produce soft cheese from camel milk **[111]**. Furthermore, soft white cheese was obtained by using STI-12, RST-743, and R-707 starter cultures **[112]**, **[113]**. A previous study showed that the calcium concentration of camel and cow milk blend cheese (449.50 mg/100g) was higher than that of camel milk cheese (325.50 mg/100g) [113]. Cheese made using starter culture showed higher cheese yield (13.22), total dry matter (44.36), fat (19.0), and protein (21.3) than cheese made by direct acidification **[114]**. However, research on camel milk cheese's chemical and other properties is still being determined.

Nowadays, camel's milk is transformed into many types of cheese, such as camembert, ricotta, halloumi, feta, etc. The Caravane cheese (also known as Camelbert) is the first camel cheese produced in Mauritania, it's one of the few commercially produced camel milk cheeses. Caravane is soft and creamy. Also, it is a very healthy cheese as it contains low lactose and fat content. Camel milk feta is made with camel milk is also creamy and has a delicate flavour. Camel milk halloumi is a variation of the traditional Cypriot cheese made from camel milk. Camel milk ricotta is a soft, fresh cheese often used in desserts or as a spread. Shubat cheese is derived from fermented camel milk with a unique tangy and rich flavor. Inayat et al. observed that fat (3.62 to 2.96), ash (11.79 to 7.30), and chloride (3.18 to 2.29) decreased in soft unripened cheese made from skimmed camel milk, but protein (44.72 to 78.88) and casein (21.17 to 59.56) increased significantly **[115]**. Although it is possible to thicken camel milk, using different cheesemaking technologies is still challenging.

Milk or fermented milk powder

Among the methods of milk preservation, drying occupies a special place, which is one of the most widespread and rational ways of creating reserves of dairy products, allowing them to reduce the cost of transporting and increase their shelf life. Food product drying methods differ in how heat is supplied to the product being dried. Several drying methods are used in the food industry, including spray drying, freeze drying, thermal radiation drying, etc.

Dried products are made by evaporating the water from the milk. Whole milk powder is obtained by drying pasteurized whole milk. It can have a mild aftertaste and a light cream color. The research has shown sufficient prospectivity of the developed technology of freeze-drying milk. The form of camel milk is powder using modern innovative technology by evaporation at low temperatures with appropriate pasteurization. Freeze drying is when a small amount of product is frozen and placed under a vacuum. Due to the removal of moisture under vacuum at low temperatures, the product's structure remains unchanged, allowing the highest quality products to be obtained **[116]**. For instance, Zou et al. reported that direct freeze-dried camel milk powder had minimum alterations in protein profile than direct spray-dried powder **[117]**. A comparative study between these two methods showed that freeze-dried camel milk powder displayed greater calcium preservation (15.33 g/kg) and iron (0.012 g/kg) **[118]**. Spray-dried whole camel milk powder had an average moisture content of 4%, total dry matter 96%, fat 29%, protein 31.6%, and lactose 29.6% **[110]**. High outlet temperature and pressure decreased vitamin C recovery during spray drying **[119]**. Overall, the freeze-drying method is recommended to obtain camel milk powder. Figure 2 shows some camel milk products produced in Kazakhstan.

Yogurt

Yogurt is a fermented milk product similar in consistency and flavor to nonfat sour cream. It is obtained by fermenting milk with specific yogurt bacteria – thermophilic *Streptococcus thermophilus* and *Bulgarian bacillus* **[120]**. The challenges and possibilities for processing camel milk into dairy products is given to assess the opportunities for developing functional camel milk products. The relative structure, distribution, and molecular composition of cow and camel milk elements are not similar. Consequently, producing camel milk products such as yogurt and cheese using the same technology as for cow milk dairy products may result in processing obstacles. However, scientific evidence indicates that it is possible to transform camel milk into products by optimizing processing parameters. The main problem of camel milk yogurt production is the texture characteristics **[121]**. In the meantime, several efforts have been made to solve the issues associated with the poor texture of fermented camel milk. Ali et al. recently prepared camel milk-soy yogurt with two different starter culture strains **[122]**. A slight increase in sensorial properties of camel milk yogurt was obtained by adding glutathione-treated transglutaminase enzyme **[123]**. It was observed that yogurt prepared from camel milk contained less protein (3.23%), fat (4.27%), lactose (3.43%), and a high amount of moisture (88.17%), ash (0.84%) as compared to yogurt prepared from cow milk **[124]**. Hashim et al. reported that cow's milk yogurt prepared using different formulations had a pH ranging from 4.3 to 4.5 and acidity ranging from 0.98 to 1.16%. In addition, yogurt prepared using 0.75% alginate and 0.075% calcium had similar sensory characteristics to cow milk yogurt **[125]**.

Balkaimak

Innovative advances are opening up opportunities to expand the range of camel milk products. “Balkaimak” is the Kazakh national dessert **[126]**. It translates as honey sour cream, i.e. “bal” – honey, “kaimak” – sour cream. For its preparation, fresh sour cream is cooked over low heat so that it does not turn into butter, and a small amount of honey and flour of the highest grade is added. Properly cooked Balkaimak has an orange color and is slightly stretchy.

Figure 2 Camel milk powder and shubat produced in Daulet-Beket. Daulet-Beket is an agricultural enterprise in Almaty region that produces mare and camel milk, and *Shubat.* (Sources: **[138]**, **[139]**).

Camel milk butter

Butter from camel is in high consumer demand due to its unique properties. However, camel milk butter production technology has significant differences compared to production from cow's milk. The butter made from camel milk differs from cow's milk by its white color and physical and chemical properties. The main problem is that camel milk slightly tends to form cream due to the lack of agglutinin, the fat distributed as small micelle-like globules, and the strong adhesion of fat to proteins. Despite this, pastoralists in Algeria make the traditional "Shmen" butter from camel's milk by churning. Also, another study revealed the possibility of obtaining butter from camel milk using high churning force but a very long churning time **[127]**. It was reported that butter made from camel milk contains more long-chain fatty acids (C14-C18) and fewer short-chain fatty acids (C4:0-C12:0) **[128]**. Several authors detected 64-65% total solids and 49-59.6% fat in camel milk butter **[129]**. Another study showed that the moisture content of butter made from pure camel milk (39.2%) was higher than butter mixed with goat milk (14.27-32.97%), while fat content was much less in butter from pure camel milk (56.8%) than butter mixed with goat milk (60.57-80%) **[130]**. However, camel's milk butter requires further research to compete with cow's milk butter production.

Camel milk ice-cream

To create a new functionally enriched ice cream that meets the requirements of the diet of ordinary, average people that would meet the dietary requirements. Thus, the development of a soft ice cream made from camel's milk is a relevant solution to several problems such as satisfying the need to to eat "sweet" without harming health and figure, as well as saturating the body with protein. Soft ice cream is usually marketed at the point of production because such ice cream is obtained after a freezing process, which in turn involves a higher defrosting temperature. The technological process of soft ice cream preparation consists of the following operations: preparation of the mixture, maturation of the mixture, and its whipping. Haijian et al. obtained low-fat ice- cream with improved sensory characteristics by enriching camel milk ice cream with 2% casein hydrolysate **[131]**. It was also suggested that using additives and flavorings in camel milk ice cream improves the nutritional value and sensory attributes **[132]**. It was observed that there was no significant difference in fat (10.1-10.2%) and protein (3.4-3.6%) content in camel milk ice cream as compared to bovine milk ice cream **[133]**.

Camel milk chocolate

Consumers like the production of chocolate milk desserts with probiotic properties based on camel milk. The study showed that the survival rate of *L. casei* in desserts prepared with camel milk was higher than those prepared with bovine milk **[134]**.

Camel beauty products

Numerous nutrients in camel milk provide natural skin protection. Alpha hydroxyl acids present in camel milk help to smooth fine lines and wrinkles, while the antimicrobial properties of camel milk act as a natural detergent, making the soap an effective treatment for skin conditions, including acne and eczema **[135]**.

Challenges in camel milk production and marketing

Many studies have proven camel milk is beneficial and close to human milk. Despite the increase in camel milk production, its consumption at the global level is limited. Due to its high cost, it is less utilized for daily milk production than other livestock's milk. Processing camel milk presents different challenges compared to bovine milk. The reason camel milk products are difficult to produce is that camel milk's composition differs significantly from cow milk. Camel milk does not show a particular tendency to coagulate, primarily due to the absence of the kappa-casein and β-lactoglobulin interactions, which causes many difficulties in producing cheese, yogurt, etc. Therefore, intensive research is needed to better understand camel milk proteins' chemical composition. Although camel milk has been subjected to numerous studies, technical analyses on an industrial scale remain scarce, especially for processed camel milk products. Further comprehensive research is needed to improve the quality of camel milk dairy products to compete with other livestock.

The results of this review indicate that various camel milk products were successfully processed due to optimization and adjustment of processing steps. The development of new technologies and improved processing methods are needed to process camel milk products intended for special dietary or medical use.

CONCLUSION

The increasing population demand for functional food products makes it necessary to investigate in depth all potential understudied and poorly known food sources. It is necessary to create new types of foods with high nutritional and biological value, providing the needs of adults and children in substances affecting the harmonious development of the organism. Producing camel milk products using the same technology as cow's milk dairy products can lead to processing. Despite these technological limitations, scientific evidence indicates that it is possible to transform camel milk into products by optimizing processing parameters. Camel milk is a nutritious beverage known for its unique composition, including various beneficial components. The protein content in camel milk varies between 2.9% to 4.9%, consisting mainly of two types: caseins and whey proteins. The fat content ranges from 1.2% to 6.4%, characterized by a higher proportion of long-chain fatty acids and a notable amount of linoleic acid and unsaturated fatty acids, essential for nutrition. Camel milk is also relatively rich in lactose, with an average of 4.4%. One of the distinguishing features of camel milk is its high vitamin content, including fat-soluble vitamins (A, E, D) and water-soluble vitamins (B, and particularly vitamin C). This makes it an excellent source of essential nutrients. Additionally, camel milk is rich in minerals, particularly calcium and potassium, vital for various bodily functions. Overall, the average composition of camel milk includes 3.1% protein, 3.5% fat, 4.4% lactose, 0.79% ash, and 11.9% total solids. The milk's low content of short-chain fatty acids and its rich profile of vitamins and minerals make it a highly nutritious option, suitable for various dietary needs.

REFERENCES

1. Burger, P. A., Ciani, E., & Faye, B. (2019). Old World camels in a modern world – a balancing act between conservation and genetic improvement. In Animal Genetics (Vol. 50, Issue 6, pp. 598–612). Wiley. https://doi.org/10.1111/age.12858
2. Ho, T. M., Zou, Z., & Bansal, N. (2022). Camel milk: A review of its nutritional value, heat stability, and potential food products. In Food Research International (Vol. 153, p. 110870). Elsevier BV. https://doi.org/10.1016/j.foodres.2021.110870
3. Behrouz, S., Saadat, S., Memarzia, A., Sarir, H., Folkerts, G., & Boskabady, M. H. (2022). The Antioxidant, Anti-Inflammatory and Immunomodulatory Effects of Camel Milk. In Frontiers in Immunology (Vol. 13). Frontiers Media SA. https://doi.org/10.3389/fimmu.2022.855342
4. Zhumabay, A., Serikbayeva, A., Kozykan, S., Yusof, Y. A., & Kozhakhmetova, A. (2023). Determination of the fatty and amino acid composition of camel milk, milk powder and shubat. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 17, pp. 918–928). HACCP Consulting. https://doi.org/10.5219/1931
5. Akhmetsadykova, S. H., Konuspayeva, G., & Akhmetsadykov, N. (2022). Camel breeding in Kazakhstan and future perspectives. In Animal Frontiers (Vol. 12, Issue 4, pp. 71–77). Oxford University Press (OUP). https://doi.org/10.1093/af/vfac048
6. Benslama, Y., Dennouni-Medjati, N., Dali-Sahi, M., Meziane, F. Z., & Harek, Y. (2021). Childhood type 1 diabetes mellitus and risk factor of interactions between dietary cow's milk intake and HLA-DR3/DR4 genotype. In Journal of Biomolecular Structure and Dynamics (Vol. 40, Issue 21, pp. 10931–10939). Informa UK Limited. https://doi.org/10.1080/07391102.2021.1953599
7. Ejtahed, H. S., Niasari Naslaji, A., Mirmiran, P., Zraif Yeganeh, M., Hedayati, M., Azizi, F., & Moosavi Movahedi, A. (2014). Effect of Camel Milk on Blood Sugar and Lipid Profile of Patients With Type 2 Diabetes: A Pilot Clinical Trial. In International Journal of Endocrinology and Metabolism (Vol. 13, Issue 1). Briefland. https://doi.org/10.5812/ijem.21160
8. Balooch Hasankhani, M., Mirzaei, H., & Karamoozian, A. (2023). Global trend analysis of diabetes mellitus incidence, mortality, and mortality-to-incidence ratio from 1990 to 2019. In Scientific Reports (Vol. 13, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41598-023-49249-0
9. Zou, Z., Duley, J. A., Cowley, D. M., Reed, S., Arachchige, B. J., Koorts, P., Shaw, P. N., & Bansal, N. (2022). Digestibility of proteins in camel milk in comparison to bovine and human milk using an in vitro infant gastrointestinal digestion system. In Food Chemistry (Vol. 374, p. 131704). Elsevier BV. https://doi.org/10.1016/j.foodchem.2021.131704
10. Konuspayeva, G., Faye, B., & Loiseau, G. (2009). The composition of camel milk: A meta-analysis of the literature data. In Journal of Food Composition and Analysis (Vol. 22, Issue 2, pp. 95–101). Elsevier BV. https://doi.org/10.1016/j.jfca.2008.09.008
11. Alhaj, O. A., Ahmad, L., Alenezi, A. F., Abodoleh, G., Ghazzawi, H., Trabelsi, K., Bragazzi, N. L., Mehta, B. M., Faye, B., & Jahrami, H. A. (2023). Does total caloric count of camel milk differ by species, country, season and year of publication: A systematic review, meta-analysis and meta-regression. In International

Journal of Dairy Technology (Vol. 77, Issue 1, pp. 15–34). Wiley. https://doi.org/10.1111/1471-0307.13017

12. Swelum, A. A., El-Saadony, M. T., Abdo, M., Ombarak, R. A., Hussein, E. O. S., Suliman, G., Alhimaidi, A. R., Ammari, A. A., Ba-Awadh, H., Taha, A. E., El-Tarabily, K. A., & Abd El-Hack, M. E. (2021). Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. In Saudi Journal of Biological Sciences (Vol. 28, Issue 5, pp. 3126–3136). Elsevier BV. https://doi.org/10.1016/j.sjbs.2021.02.057

13. Benmeziane – Derradji, F. (2021). Evaluation of camel milk: gross composition—a scientific overview. In Tropical Animal Health and Production (Vol. 53, Issue 2). Springer Science and Business Media LLC. https://doi.org/10.1007/s11250-021-02689-0

14. Alhaj, O. A., Lajnaf, R., Jrad, Z., Alshuniaber, M. A., Jahrami, H. A., & Serag El-Din, M. F. (2022). Comparison of Ethanol Stability and Chemical Composition of Camel Milk from Five Samples. In Animals (Vol. 12, Issue 5, p. 615). MDPI AG. https://doi.org/10.3390/ani12050615

15. Hailu, Y., Hansen, E. B., Seifu, E., Eshetu, M., Ipsen, R., & Kappeler, S. (2016). Functional and technological properties of camel milk proteins: a review. In Journal of Dairy Research (Vol. 83, Issue 4, pp. 422–429). Cambridge University Press (CUP). https://doi.org/10.1017/s0022029916000686

16. Wal, J.-M. (2002). Cow's milk proteins/allergens. In Annals of Allergy, Asthma & Immunology (Vol. 89, Issue 6, pp. 3–10). Elsevier BV. https://doi.org/10.1016/s1081-1206(10)62115-1

17. Mbye, M., Ayyash, M., Abu-Jdayil, B., & Kamal-Eldin, A. (2022). The Texture of Camel Milk Cheese: Effects of Milk Composition, Coagulants, and Processing Conditions. In Frontiers in Nutrition (Vol. 9). Frontiers Media SA. https://doi.org/10.3389/fnut.2022.868320

18. Laleye, L. C., Jobe, B., & Wasesa, A. A. H. (2008). Comparative Study on Heat Stability and Functionality of Camel and Bovine Milk Whey Proteins. In Journal of Dairy Science (Vol. 91, Issue 12, pp. 4527–4534). American Dairy Science Association. https://doi.org/10.3168/jds.2008-1446

19. Kumar, D., Verma, A. K., Chatli, M. K., Singh, R., Kumar, P., Mehta, N., & Malav, O. P. (2016). Camel milk: alternative milk for human consumption and its health benefits. In Nutrition & Food Science (Vol. 46, Issue 2, pp. 217–227). Emerald. https://doi.org/10.1108/nfs-07-2015-0085

20. Hinz, K., O'Connor, P. M., Huppertz, T., Ross, R. P., & Kelly, A. L. (2012). Comparison of the principal proteins in bovine, caprine, buffalo, equine and camel milk. In Journal of Dairy Research (Vol. 79, Issue 2, pp. 185–191). Cambridge University Press (CUP). https://doi.org/10.1017/s0022029912000015

21. Yang, Y., Bu, D., Zhao, X., Sun, P., Wang, J., & Zhou, L. (2013). Proteomic Analysis of Cow, Yak, Buffalo, Goat and Camel Milk Whey Proteins: Quantitative Differential Expression Patterns. In Journal of Proteome Research (Vol. 12, Issue 4, pp. 1660–1667). American Chemical Society (ACS). https://doi.org/10.1021/pr301001m

22. Talarico, V., Mazza, G., Rubino, M., Monti, G., Giancotti, L., Bua, A., Mohamed, A. M., & Miniero, R. (2021). Camel milk: a possible alternative for children with cow's milk allergy? In Minerva Pediatrics (Vol. 73, Issue 4). Edizioni Minerva Medica. https://doi.org/10.23736/s2724-5276.19.05632-9

23. Habib, H. M., Ibrahim, W. H., Schneider-Stock, R., & Hassan, H. M. (2013). Camel milk lactoferrin reduces the proliferation of colorectal cancer cells and exerts antioxidant and DNA damage inhibitory activities. In Food Chemistry (Vol. 141, Issue 1, pp. 148–152). Elsevier BV. https://doi.org/10.1016/j.foodchem.2013.03.039

24. Alkhulaifi, M. M., Alosaimi, M. M., Khan, M. S., Tabrez, S., Shaik, G. M., Alokail, M. S., Hassan, M. A., Awadalla, M. E., & Husain, F. M. (2023). Assessment of Broad-Spectrum Antimicrobial, Antibiofilm, and Anticancer Potential of Lactoferrin Extracted from Camel Milk. In Applied Biochemistry and Biotechnology. Springer Science and Business Media LLC. https://doi.org/10.1007/s12010-023-04579-7

25. Konuspayeva, G., Faye, B., Loiseau, G., & Levieux, D. (2007). Lactoferrin and Immunoglobulin Contents in Camel's Milk (Camelus bactrianus, Camelus dromedarius, and Hybrids) from Kazakhstan. In Journal of Dairy Science (Vol. 90, Issue 1, pp. 38–46). American Dairy Science Association. https://doi.org/10.3168/jds.s0022-0302(07)72606-1

26. El-Hatmi, H., Levieux, A., & Levieux, D. (2006). Camel (Camelus dromedarius) immunoglobulin G, α-lactalbumin, serum albumin and lactoferrin in colostrum and milk during the early post partum period. In Journal of Dairy Research (Vol. 73, Issue 3, pp. 288–293). Cambridge University Press (CUP). https://doi.org/10.1017/s0022029906001713

27. Arain, M. A., Khaskheli, G. B., Shah, A. H., Marghazani, I. B., Barham, G. S., Shah, Q. A., Khand, F. M., Buzdar, J. A., Soomro, F., & Fazlani, S. A. (2022). Nutritional significance and promising therapeutic/medicinal application of camel milk as a functional food in human and animals: a comprehensive review. In Animal Biotechnology (Vol. 34, Issue 6, pp. 1988–2005). Informa UK Limited. https://doi.org/10.1080/10495398.2022.2059490

28. Elagamy, E. I., Ruppanner, R., Ismail, A., Champagne, C. P., & Assaf, R. (1996). Purification and characterization of lactoferrin, lactoperoxidase, lysozyme and immunoglobulins from camel's milk. In International Dairy Journal (Vol. 6, Issue 2, pp. 129–145). Elsevier BV. https://doi.org/10.1016/0958-6946(94)00055-7
29. Zhang, H., Yao, J., Zhao, D., Liu, H., Li, J., & Guo, M. (2005). Changes in Chemical Composition of Alxa Bactrian Camel Milk During Lactation. In Journal of Dairy Science (Vol. 88, Issue 10, pp. 3402–3410). American Dairy Science Association. https://doi.org/10.3168/jds.s0022-0302(05)73024-1
30. Li, X., Li, Z., Xu, E., Chen, L., Feng, H., Chen, L., Deng, L., & Guo, D. (2019). Determination of Lactoferrin in Camel Milk by Ultrahigh-Performance Liquid Chromatography-Tandem Mass Spectrometry Using an Isotope-Labeled Winged Peptide as Internal Standard. In Molecules (Vol. 24, Issue 22, p. 4199). MDPI AG. https://doi.org/10.3390/molecules24224199
31. Ipsen, R. (2017). Opportunities for Producing Dairy Products from Camel Milk: A Comparison with Bovine Milk. East African Journal of Sciences, Vol. 11 No. 2 (2017): East African Journal of Sciences. https://doi.org/10.20372/EAJS.V11I2.404
32. Konuspayeva, G., Faye, B., Loiseau, G., & Levieux, D. (2007). Lactoferrin and Immunoglobulin Contents in Camel's Milk (Camelus bactrianus, Camelus dromedarius, and Hybrids) from Kazakhstan. In Journal of Dairy Science (Vol. 90, Issue 1, pp. 38–46). American Dairy Science Association. https://doi.org/10.3168/jds.s0022-0302(07)72606-1
33. Rafiq, S., Huma, N., Pasha, I., Sameen, A., Mukhtar, O., & Khan, M. I. (2015). Chemical Composition, Nitrogen Fractions and Amino Acids Profile of Milk from Different Animal Species. In Asian-Australasian Journal of Animal Sciences (Vol. 29, Issue 7, pp. 1022–1028). Asian Australasian Association of Animal Production Societies. https://doi.org/10.5713/ajas.15.0452
34. He, J., Xiao, Y., Orgoldol, K., Ming, L., Yi, L., & Ji, R. (2019). Effects of Geographic Region on the Composition of Bactrian Camel Milk in Mongolia. In Animals (Vol. 9, Issue 11, p. 890). MDPI AG. https://doi.org/10.3390/ani9110890
35. Stahl, T., Sallmann, H. P., & Duehlmeier, R. (2006). Selected vitamins and fatty acid patterns in dromedary milk and colostrum. In Journal of Camel Practice and Research (Vol. 13, Issue 1, pp. 53–57). Camel Publishing House.
36. Bouhaddaoui, S., Chabir, R., Errachidi, F., El Ghadraoui, L., El Khalfi, B., Benjelloun, M., & Soukri, A. (2019). Study of the Biochemical Biodiversity of Camel Milk. In The Scientific World Journal (Vol. 2019, pp. 1–7). Hindawi Limited. https://doi.org/10.1155/2019/2517293
37. Miao, J., Xiao, S., & Wang, J. (2023). Comparative Study of Camel Milk from Different Areas of Xinjiang Province in China. In Food Science of Animal Resources (Vol. 43, Issue 4, pp. 674–684). Korean Society for Food Science of Animal Resources. https://doi.org/10.5851/kosfa.2023.e27
38. Konuspayeva, G., Faye, B., & Loiseau, G. (2011). Variability of vitamin C content in camel milk from Kazakhstan. In Journal of Camelid Science (Vol. 4, pp. 63–69). International society of Camelid Research and Development.
39. Wang, S. Y., Liang, J. P., Shao, W., & Wen, H. (2011). Mineral, vitamin and fatty acid contents in the camel milk of dromedaries in the anxi gansu China. In Journal of Camel Practice and Research (Vol. 18, Issue 2, pp. 273–276). Camel Publishing House.
40. Mostafidi, M., Moslehishad, M., Piravivanak, Z., & Pouretedal, Z. (2016). Evaluation of mineral content and heavy metals of dromedary camel milk in Iran. In Food Science and Technology (Vol. 36, Issue 4, pp. 717–723). FapUNIFESP (SciELO). https://doi.org/10.1590/1678-457x.16116
41. Soliman, G. Z. A. (2005). Comparison Of Chemical And Mineral Content Of Milk From Human, Cow, Buffalo, Camel And Goat In Egypt. In The Egyptian Journal of Hospital Medicine (Vol. 21, Issue 1, pp. 116–130). Egypts Presidential Specialized Council for Education and Scientific Research. https://doi.org/10.21608/ejhm.2005.18054
42. Faye, B., & Bengoumi, M. (2018). Camel clinical biochemistry and hematology. New-York: Springer Publ.; p. 346.
43. Konuspayeva, G., Lemarie, É., Faye, B., Loiseau, G., & Montet, D. (2008). Fatty acid and cholesterol composition of camel's (Camelus bactrianus, Camelus dromedariusand hybrids) milk in Kazakhstan. In Dairy Science and Technology (Vol. 88, Issue 3, pp. 327–340). Springer Science and Business Media LLC. https://doi.org/10.1051/dst:2008005

44. Faye, B., Bengoumi, M., Al-Masaud, A., & Konuspayeva, G. (2015). Comparative milk and serum cholesterol content in dairy cow and camel. In Journal of King Saud University - Science (Vol. 27, Issue 2, pp. 168–175). Elsevier BV. https://doi.org/10.1016/j.jksus.2014.11.003
45. Swelum, A. A., El-Saadony, M. T., Abdo, M., Ombarak, R. A., Hussein, E. O. S., Suliman, G., Alhimaidi, A. R., Ammari, A. A., Ba-Awadh, H., Taha, A. E., El-Tarabily, K. A., & Abd El-Hack, M. E. (2021). Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. In Saudi Journal of Biological Sciences (Vol. 28, Issue 5, pp. 3126–3136). Elsevier BV. https://doi.org/10.1016/j.sjbs.2021.02.057
46. Wang, F., Chen, M., Luo, R., Huang, G., Wu, X., Zheng, N., Zhang, Y., & Wang, J. (2022). Fatty acid profiles of milk from Holstein cows, Jersey cows, buffalos, yaks, humans, goats, camels, and donkeys based on gas chromatography–mass spectrometry. In Journal of Dairy Science (Vol. 105, Issue 2, pp. 1687–1700). American Dairy Science Association. https://doi.org/10.3168/jds.2021-20750
47. Chamekh, L., Calvo, M., Khorchani, T., Castro-Gómez, P., Hammadi, M., Fontecha, J., & Yahyaoui, M. H. (2020). Impact of management system and lactation stage on fatty acid composition of camel milk. In Journal of Food Composition and Analysis (Vol. 87, p. 103418). Elsevier BV. https://doi.org/10.1016/j.jfca.2020.103418
48. Zou, Z., Duley, J. A., Cowley, D. M., Reed, S., Arachchige, B. J., Shaw, P. N., & Bansal, N. (2022). Comprehensive biochemical and proteomic characterization of seasonal Australian camel milk. In Food Chemistry (Vol. 381, p. 132297). Elsevier BV. https://doi.org/10.1016/j.foodchem.2022.132297
49. Swelum, A. A.-A., Saadeldin, I. M., Abdelnour, S. A., Ba-Awadh, H., Abd El-Hack, M. E., & Sheiha, A. M. (2019). Relationship between concentrations of macro and trace elements in serum and follicular, oviductal, and uterine fluids of the dromedary camel (Camelus dromedarius). In Tropical Animal Health and Production (Vol. 52, Issue 3, pp. 1315–1324). Springer Science and Business Media LLC. https://doi.org/10.1007/s11250-019-02137-0
50. Raziq, A., Younas, M. T., Khan, M. S., & Iqbal, A. (2010). Milk production potential as affected by parity and age in the Kohi dromedary camel. In Journal of Camel Practice and Research (Vol. 17, Issue 2, pp. 195–198). Camel Publishing House.
51. Musaad, A., Faye, B., & Nikhela, A. A. (2012). Lactation curves of dairy camels in an intensive system. In Tropical Animal Health and Production (Vol. 45, Issue 4, pp. 1039–1046). Springer Science and Business Media LLC. https://doi.org/10.1007/s11250-012-0331-x
52. Faye, B. (2008). Dairy productivity potential of camels. In: Cardellion, R., Rosati A., and Mosconi C., editors. Current status of genetic resources, recording and production systems in African, Asian and American Camelids. ICAR, Rome, Italy: ICAR technical series No. 11, Proceedings of the ICAR/FAO Seminar; p. 93–104.
53. Ahmad, S., Yaqoob, M., Bilal, M. Q., Khan, M. K., Muhammad, G., Yang, L.-G., & Tariq, M. (2012). Factors affecting yield and composition of camel milk kept under desert conditions of central Punjab, Pakistan. In Tropical Animal Health and Production (Vol. 44, Issue 7, pp. 1403–1410). Springer Science and Business Media LLC. https://doi.org/10.1007/s11250-012-0079-3
54. Khan, B. B., & Iqbal, A. (2001). Production and composition of camel milk - review. In Pakistan Journal of Agricultural Sciences (Vol. 38, pp. 64–68). Pakistan Association of Advancement in Agricultural Sciences.
55. Kaskous, S., Al-Momani, A. Q., Al-Yacoub, A. N., & Al-Najjar, K. A. (2021). Physiological Perspective of Milk Somatic Cell Count in Lactating Camels. In Journal of Camel Practice and Research (Vol. 28, Issue 3, pp. 319–325). Diva Enterprises Private Limited. https://doi.org/10.5958/2277-8934.2021.00049.7
56. El -Ziney, M. G. (2007). Microbiological quality and safety assessment of camel milk (camelus dromedaries) in saudi arabia (qassim region). In Applied Ecology and Environmental Research (Vol. 5, Issue 2, pp. 115–122). ALOKI Ltd. https://doi.org/10.15666/aeer/0502_115122
57. Alaoui Ismaili, M., Saidi, B., Zahar, M., Hamama, A., & Ezzaier, R. (2019). Composition and microbial quality of raw camel milk produced in Morocco. In Journal of the Saudi Society of Agricultural Sciences (Vol. 18, Issue 1, pp. 17–21). Elsevier BV. https://doi.org/10.1016/j.jssas.2016.12.001
58. Garcell, H. G., Garcia, E. G., Pueyo, P. V., Martín, I. R., Arias, A. V., & Alfonso Serrano, R. N. (2016). Outbreaks of brucellosis related to the consumption of unpasteurized camel milk. In Journal of Infection and Public Health (Vol. 9, Issue 4, pp. 523–527). Elsevier BV. https://doi.org/10.1016/j.jiph.2015.12.006
59. Alnassrallah, M. N., Alzoman, N. Z., & Almomen, A. (2022). Qualitative immunoassay for the determination of tetracycline antibiotic residues in milk samples followed by a quantitative improved HPLC-DAD method. In Scientific Reports (Vol. 12, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41598-022-18886-2

60. Zhumabay, A. N., Serikbayeva, A. D., Myrzabek, K. A., & Musulmanova, M. M. (2023). Microbiological analysis of raw camel milk, dry camel milk and shubat from a farm in Almaty region. In Journal of Microbiology and Virology (Vol. 2, Issue 41, pp. 167–172). Research and Production Center for Microbiology and Virology. https://doi.org/10.53729/MV-AS.2023.02.10

61. Konuspayeva, G., & Faye, B. (2021). Recent Advances in Camel Milk Processing. In Animals (Vol. 11, Issue 4, p. 1045). MDPI AG. https://doi.org/10.3390/ani11041045

62. Hassan, R. A., El Zubeir, I. E. M., & Babiker, S. A. (2007). Effect of Pasteurization of Raw Camel Milk and Storage Temperature on the Chemical Composition of Fermented Camel Milk. In International Journal of Dairy Science (Vol. 2, Issue 2, pp. 166–171). Science Alert. https://doi.org/10.3923/ijds.2007.166.171

63. Ayyash, M., Abdalla, A., Abu-Jdayil, B., Huppertz, T., Bhaskaracharya, R., Al-Mardeai, S., Mairpady, A., Ranasinghe, A., & Al-Nabulsi, A. (2022). Rheological properties of fermented milk from heated and high pressure-treated camel milk and bovine milk. In LWT (Vol. 156, p. 113029). Elsevier BV. https://doi.org/10.1016/j.lwt.2021.113029

64. Alharbi, Y. M., Sakr, S. S., Albarrak, S. M., Almundarij, T. I., Barakat, H., & Hassan, M. F. Y. (2022). Antioxidative, Antidiabetic, and Hypolipidemic Properties of Probiotic-Enriched Fermented Camel Milk Combined with Salvia officinalis Leaves Hydroalcoholic Extract in Streptozotocin-Induced Diabetes in Rats. In Antioxidants (Vol. 11, Issue 4, p. 668). MDPI AG. https://doi.org/10.3390/antiox11040668

65. De Filippis, F., Pasolli, E., & Ercolini, D. (2020). The food-gut axis: lactic acid bacteria and their link to food, the gut microbiome and human health. In FEMS Microbiology Reviews (Vol. 44, Issue 4, pp. 454–489). Oxford University Press (OUP). https://doi.org/10.1093/femsre/fuaa015

66. Gupta, V., & Garg, R. (2009). PROBIOTICS. In Indian Journal of Medical Microbiology (Vol. 27, Issue 3, pp. 202–209). Elsevier BV. https://doi.org/10.4103/0255-0857.53201

67. Rahmeh, R., Akbar, A., Kishk, M., Al-Onaizi, T., Al-Azmi, A., Al-Shatti, A., Shajan, A., Al-Mutairi, S., & Akbar, B. (2019). Distribution and antimicrobial activity of lactic acid bacteria from raw camel milk. In New Microbes and New Infections (Vol. 30, p. 100560). Elsevier BV. https://doi.org/10.1016/j.nmni.2019.100560

68. Sharma, A., Lavania, M., Singh, R., & Lal, B. (2021). Identification and probiotic potential of lactic acid bacteria from camel milk. In Saudi Journal of Biological Sciences (Vol. 28, Issue 3, pp. 1622–1632). Elsevier BV. https://doi.org/10.1016/j.sjbs.2020.11.062

69. Nagyzbekkyzy, E., Sembayeva, D., Sarsenova, A., Mansurov, N., Moldabayeva, A., & Moldagulova, N. (2020). Data on the diversity of lactic acid bacteria isolated from raw and fermented camel milk. In Data in Brief (Vol. 31, p. 105956). Elsevier BV. https://doi.org/10.1016/j.dib.2020.105956

70. Khedid, K., Faid, M., Mokhtari, A., Soulaymani, A., & Zinedine, A. (2009). Characterization of lactic acid bacteria isolated from the one humped camel milk produced in Morocco. In Microbiological Research (Vol. 164, Issue 1, pp. 81–91). Elsevier BV. https://doi.org/10.1016/j.micres.2006.10.008

71. Zhao, J., Fan, H., Kwok, L.-Y., Guo, F., Ji, R., Ya, M., & Chen, Y. (2020). Analyses of physicochemical properties, bacterial microbiota, and lactic acid bacteria of fresh camel milk collected in Inner Mongolia. In Journal of Dairy Science (Vol. 103, Issue 1, pp. 106–116). American Dairy Science Association. https://doi.org/10.3168/jds.2019-17023

72. Bin Masalam, M. S., Bahieldin, A., Alharbi, M. G., Al-Masaudi, S., Al-Jaouni, S. K., Harakeh, S. M., & Al-Hindi, R. R. (2018). Isolation, Molecular Characterization and Probiotic Potential of Lactic Acid Bacteria in Saudi Raw and Fermented Milk. In Evidence-Based Complementary and Alternative Medicine (Vol. 2018, pp. 1–12). Hindawi Limited. https://doi.org/10.1155/2018/7970463

73. Kadri, Z., Spitaels, F., Cnockaert, M., Praet, J., El Farricha, O., Swings, J., & Vandamme, P. (2015). Enterococcus bulliens sp. nov., a novel lactic acid bacterium isolated from camel milk. In Antonie van Leeuwenhoek (Vol. 108, Issue 5, pp. 1257–1265). Springer Science and Business Media LLC. https://doi.org/10.1007/s10482-015-0579-z

74. Yu, Z., Peng, C., Kwok, L., & Zhang, H. (2021). The Bacterial Diversity of Spontaneously Fermented Dairy Products Collected in Northeast Asia. In Foods (Vol. 10, Issue 10, p. 2321). MDPI AG. https://doi.org/10.3390/foods10102321

75. Davati, N., Yazdi, F. T., Zibaee, S., Shahidi, F., & Edalatian, M. R. (2015). Study of Lactic Acid Bacteria Community From Raw Milk of Iranian One Humped Camel and Evaluation of Their Probiotic Properties. In Jundishapur Journal of Microbiology (Vol. 8, Issue 5). Briefland. https://doi.org/10.5812/jjm.8(5)2015.16750

76. Moussaid, S., Bouhlal, O., Benali, A., Kabbour, M. R., Ounine, K., & El Maadoudi, E. H. (2021). Technological characterization of indigenous lactic acid bacteria from Moroccan camel milk for their potential use as starter or adjunct culture. In Folia Microbiologica (Vol. 66, Issue 5, pp. 761–774). Springer Science and Business Media LLC. https://doi.org/10.1007/s12223-021-00885-x

77. Edalati, E., Saneei, B., Alizadeh, M., Hosseini, S. S., Zahedi Bialvaei, A., & Taheri, K. (2019). Isolation of probiotic bacteria from raw camel's milk and their antagonistic effects on two bacteria causing food poisoning. In New Microbes and New Infections (Vol. 27, pp. 64–68). Elsevier BV. https://doi.org/10.1016/j.nmni.2018.11.008
78. Baig, M. A., Turner, M. S., Liu, S.-Q., Shah, N. N., & Ayyash, M. M. (2022). Heat, cold, acid, and bile salt induced differential proteomic responses of a novel potential probiotic Lactococcus garvieae C47 isolated from camel milk. In Food Chemistry (Vol. 397, p. 133774). Elsevier BV. https://doi.org/10.1016/j.foodchem.2022.133774
79. Kadri, Z., Spitaels, F., Cnockaert, M., Amar, M., Joossens, M., & Vandamme, P. (2021). The bacterial diversity of raw Moroccon camel milk. In International Journal of Food Microbiology (Vol. 341, p. 109050). Elsevier BV. https://doi.org/10.1016/j.ijfoodmicro.2021.109050
80. Elbanna, K., El Hadad, S., Assaeedi, A., Aldahlawi, A., Khider, M., & Alhebshi, A. (2018). In vitro and in vivo evidences for innate immune stimulators lactic acid bacterial starters isolated from fermented camel dairy products. In Scientific Reports (Vol. 8, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41598-018-31006-3
81. Ishii, S., Nurtazin, S. (2014). Properties of camel milk liquor ("shubat") in the Republic of Kazakhstan. In Milk Science (Vol. 63, Issue 2, pp. 55–62). Japanese Dairy Science Association. https://doi.org/10.11465/milk.63.55
82. Takeda, S., Yamasaki, K., Takeshita, M., Kikuchi, Y., Tsend-Ayush, C., Dashnyam, B., Ahhmed, A. M., Kawahara, S., & Muguruma, M. (2011). The investigation of probiotic potential of lactic acid bacteria isolated from traditional Mongolian dairy products. In Animal Science Journal (Vol. 82, Issue 4, pp. 571–579). Wiley. https://doi.org/10.1111/j.1740-0929.2011.00874.x
83. Xu, R. H., Xiu, L., Zhang, Y. L., Du, R. P., & Wang, X. (2019). Probiotic and hepatoprotective activity of lactobacillus isolated from Mongolian camel milk products. In Beneficial Microbes (Vol. 10, Issue 6, pp. 699–710). Wageningen Academic Publishers. https://doi.org/10.3920/bm2018.0131
84. Mercha, I., Lakram, N., Kabbour, M. R., Bouksaim, M., Zkhiri, F., & El Maadoudi, E. H. (2020). Probiotic and technological features of Enterococcus and Weissella isolates from camel milk characterised by an Argane feeding regimen. In Archives of Microbiology (Vol. 202, Issue 8, pp. 2207–2219). Springer Science and Business Media LLC. https://doi.org/10.1007/s00203-020-01944-6
85. Berhe, T., Ipsen, R., Seifu, E., Kurtu, M. Y., Fugl, A., & Hansen, E. B. (2019). Metagenomic analysis of bacterial community composition in Dhanaan: Ethiopian traditional fermented camel milk. In FEMS Microbiology Letters (Vol. 366, Issue 11). Oxford University Press (OUP). https://doi.org/10.1093/femsle/fnz128
86. Forooghi Nia, F., Rahmati, A., Ariamanesh, M., Saeidi, J., Ghasemi, A., & Mohtashami, M. (2023). The Anti-Helicobacter pylori effects of Limosilactobacillus reuteri strain 2892 isolated from Camel milk in C57BL/6 mice. In World Journal of Microbiology and Biotechnology (Vol. 39, Issue 5). Springer Science and Business Media LLC. https://doi.org/10.1007/s11274-023-03555-x
87. Kordesedehi, R., Taheri-Kafrani, A., Rabbani-Khorasgani, M., Kazemi, R., Mutangadura, D., & Haertle, T. (2018). Modification of IgE binding to αS1-casein by proteolytic activity of Enterococcus faecium isolated from Iranian camel milk samples. In Journal of Biotechnology (Vols. 276–277, pp. 10–14). Elsevier BV. https://doi.org/10.1016/j.jbiotec.2018.04.005
88. Benmechernene, Z., Fernández-No, I., Quintela-Baluja, M., Böhme, K., Kihal, M., Calo-Mata, P., & Barros-Velázquez, J. (2014). Genomic and Proteomic Characterization of Bacteriocin-ProducingLeuconostoc mesenteroidesStrains Isolated from Raw Camel Milk in Two Southwest Algerian Arid Zones. In BioMed Research International (Vol. 2014, pp. 1–10). Hindawi Limited. https://doi.org/10.1155/2014/853238
89. Derriche, I., Nogacka, A. M., Salazar, N., Ruas-Madiedo, P., Gueimonde, M., Bensalah, F., & de los Reyes-Gavilán, C. G. (2020). Effect of inulin-type fructans and galactooligosaccharides on cultures of Lactobacillus strains isolated in Algeria from camel's milk and human colostrum. In Food Science and Technology International (Vol. 27, Issue 3, pp. 223–233). SAGE Publications. https://doi.org/10.1177/1082013220944661
90. Chouikhi, A., Ktari, N., Bardaa, S., Hzami, A., Ben Slima, S., Trabelsi, I., Asehraou, A., & Ben Salah, R. (2021). A novel probiotic strain, Lactiplantibacillus plantarum LC38, isolated from Tunisian camel milk promoting wound healing in Wistar diabetic rats. In Archives of Microbiology (Vol. 204, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1007/s00203-021-02634-7

91. Abushelaibi, A., Al-Mahadin, S., El-Tarabily, K., Shah, N. P., & Ayyash, M. (2017). Characterization of potential probiotic lactic acid bacteria isolated from camel milk. In LWT - Food Science and Technology (Vol. 79, pp. 316–325). Elsevier BV. https://doi.org/10.1016/j.lwt.2017.01.041

92. Fguiri, I., Ziadi, M., Atigui, M., Ayeb, N., Arroum, S., Assadi, M., & Khorchani, T. (2015). Isolation and characterisation of lactic acid bacteria strains from raw camel milk for potential use in the production of fermented Tunisian dairy products. In International Journal of Dairy Technology (Vol. 69, Issue 1, pp. 103–113). Wiley. https://doi.org/10.1111/1471-0307.12226

93. Hawaz, E., Guesh, T., Kebede, A., & Menkir, S. (2016). Characterization of Lactic Acid Bacteria from Camel Milk and their Technological Properties to Use as a Starter Culture. East African Journal of Sciences, Vol. 10 No. 1 (2016): East African Journal of Sciences. https://doi.org/10.20372/EAJS.V10I1.320

94. Fugl, A., Berhe, T., Kiran, A., Hussain, S., Laursen, M. F., Bahl, M. I., Hailu, Y., Sørensen, K. I., Guya, M. E., Ipsen, R., & Hansen, E. B. (2017). Characterisation of lactic acid bacteria in spontaneously fermented camel milk and selection of strains for fermentation of camel milk. In International Dairy Journal (Vol. 73, pp. 19–24). Elsevier BV. https://doi.org/10.1016/j.idairyj.2017.04.007

95. Soleymanzadeh, N., Mirdamadi, S., & Kianirad, M. (2016). Antioxidant activity of camel and bovine milk fermented by lactic acid bacteria isolated from traditional fermented camel milk (Chal). In Dairy Science & Technology (Vol. 96, Issue 4, pp. 443–457). Springer Science and Business Media LLC. https://doi.org/10.1007/s13594-016-0278-1

96. Jans, C., Bugnard, J., Njage, P. M. K., Lacroix, C., & Meile, L. (2012). Lactic acid bacteria diversity of African raw and fermented camel milk products reveals a highly competitive, potentially health-threatening predominant microflora. In LWT (Vol. 47, Issue 2, pp. 371–379). Elsevier BV. https://doi.org/10.1016/j.lwt.2012.01.034

97. Ashmaig, A., Hasan, A. M., & Gaali, E. I. (2009). Identification of lactic acid bacteria isolated from traditional Sudanese fermented camel's milk (Gariss). In African Journal of Microbiology Research (Vol. 3, Issue 8, pp. 451–457). Academic Journals.

98. Carballo, J. (2016). Potential technological interest of indigenous lactic acid bacteria from algerian camel milk [JB]. In Italian Journal of Food Science (Vol. 28, Issue 4, pp. 598–611). Codon Publications. https://doi.org/10.14674/1120-1770/ijfs.v391

99. Mourad, K., & Nour-Eddine, K. (2006). Physicochemical and microbiological study of a traditional butter made from camel milk in the Sahara (Algeria): isolation and identification of lactic acid bacteria and yeasts. In Grasas y Aceites (Vol. 57, Issue 2). Editorial CSIC. https://doi.org/10.3989/gya.2006.v57.i2.37

100. Konuspayeva, G., Baubekova, A., Akhmetsadykova, S., & Faye, B. (2023). Traditional dairy fermented products in Central Asia. In International Dairy Journal (Vol. 137, p. 105514). Elsevier BV. https://doi.org/10.1016/j.idairyj.2022.105514

101. Serikbayeva, A., Konuspayeva, G., Faye, B., Loiseau, G., Narmuratova, M. K., & Esenov, P. (2005). Probiotic properties of a sour-milk product: shubat from the camel milk. In Proceedings of the NATO Advanced Research Workshop, 19-21 April 2004, Ashgabad, Turkmenistan (Vol. 362, pp. 187–191). IOS press.

102. Rahman, I. E., Dirar, H. A., & Osman, M. A. (2009). Microbiological and biochemical changes and sensory evaluation of camel milk fermented by selected bacterial starter cultures. In African Journal of Food Science (Vol. 3, pp. 398–405). Academic Journals.

103. Manaer, T., Yu, L., Zhang, Y., Xiao, X.-J., & Nabi, X.-H. (2015). Anti-diabetic effects of shubat in type 2 diabetic rats induced by combination of high-glucose-fat diet and low-dose streptozotocin. In Journal of Ethnopharmacology (Vol. 169, pp. 269–274). Elsevier BV. https://doi.org/10.1016/j.jep.2015.04.032

104. Urazakov, N. U., & Baĭnazarov, S. H. (1974). "Tushibek" - pervaia v istorii shubatolechebnitsa ["Tushchibek" - the 1st clinic in history for the treatment of pulmonary tuberculosis with camel's sour milk]. In Problemy tuberkuleza (Vol. 2, pp. 89–90). Moskva : Medit͡sina, -2003.

105. Sulieman, A. M. E., & Alayan, A. A. (2022). Nutritional, Antimicrobial and Bioactive Components of Gariss, a Fermented Camel Milk Product. In African Fermented Food Products- New Trends (pp. 175–187). Springer International Publishing. https://doi.org/10.1007/978-3-030-82902-5_12

106. Shori, A. B. (2012). Comparative study of chemical composition, isolation and identification of micro-flora in traditional fermented camel milk products: Gariss, Suusac, and Shubat. In Journal of the Saudi Society of Agricultural Sciences (Vol. 11, Issue 2, pp. 79–88). Elsevier BV. https://doi.org/10.1016/j.jssas.2011.12.001

107. Lore, T. A., Mbugua, S. K., & Wangoh, J. (2005). Enumeration and identification of microflora in suusac, a Kenyan traditional fermented camel milk product. In LWT - Food Science and Technology (Vol. 38, Issue 2, pp. 125–130). Elsevier BV. https://doi.org/10.1016/j.lwt.2004.05.008

108. Konuspayeva, G. S. (2020). Manufacture and Challenges of Camel Milk Cheese. In Handbook of Research on Health and Environmental Benefits of Camel Products (pp. 110–122). IGI Global. https://doi.org/10.4018/978-1-7998-1604-1.ch006

109. Abdalla, A., Abu-Jdayil, B., AlMadhani, S., Hamed, F., Kamal-Eldin, A., Huppertz, T., & Ayyash, M. (2022). Low-fat akawi cheese made from bovine-camel milk blends: Rheological properties and microstructural characteristics. In Journal of Dairy Science (Vol. 105, Issue 6, pp. 4843–4856). American Dairy Science Association. https://doi.org/10.3168/jds.2021-21367

110. Ramet, J. P. (2001). The technology of making cheese from camel milk (Camelus dromedarius). In Food & Agriculture Organization (p. 62). FAO

111. Al-zoreky, N. S., & Almathen, F. S. (2021). Using recombinant camel chymosin to make white soft cheese from camel milk. In Food Chemistry (Vol. 337, p. 127994). Elsevier BV. https://doi.org/10.1016/j.foodchem.2020.127994

112. Bekele, B., Hansen, E. B., Eshetu, M., Ipsen, R., & Hailu, Y. (2019). Effect of starter cultures on properties of soft white cheese made from camel (Camelus dromedarius) milk. In Journal of Dairy Science (Vol. 102, Issue 2, pp. 1108–1115). American Dairy Science Association. https://doi.org/10.3168/jds.2018-15084

113. Mahgoub, S., & Sulieman, A. M. E. (2022). Production and Quality Assessment of Camel Milk Cheese. In African Fermented Food Products- New Trends (pp. 189–202). Springer International Publishing. https://doi.org/10.1007/978-3-030-82902-5_13

114. Khan, H. I., Athar, I. H., Aslam, M. Z., & Moorat, K. (2004). Evaluation of Cheese Prepared by Processing Camel Milk. In Pakistan Journal of Zoology (Vol. 36, Issue 4, pp. 323–326). University of Punjab (new Campus).

115. Inayat, S., Arain, M. A., Khaskheli, M., & Mali, A. H. (2003). Study of the Effect of Processing on the Chemical Quality of Soft Unripened Cheese Made from Camel Milk. In Pakistan Journal of Nutrition (Vol. 2, pp. 102–105). Asian Network for Scientific Information. https://doi.org/10.3923/pjn.2003.102.105

116. Chandramohan, V. P. (2022). Experimental Analysis of Freeze Drying and Estimating the Transient Moisture Contents of Food Products. In Energy and Exergy for Sustainable and Clean Environment, Volume 2 (pp. 535–546). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-8274-2_36

117. Zou, Z., Duley, J. A., Cowley, D. M., Reed, S., Arachchige, B. J., Bhandari, B., Shaw, P. N., & Bansal, N. (2022). Physicochemical Properties and Whey Proteomes of Camel Milk Powders Produced by Different Concentration and Dehydration Processes. In Foods (Vol. 11, Issue 5, p. 727). MDPI AG. https://doi.org/10.3390/foods11050727

118. Deshwal, G. K., Singh, A. K., Kumar, D., & Sharma, H. (2020). Effect of spray and freeze drying on physico-chemical, functional, moisture sorption and morphological characteristics of camel milk powder. In LWT (Vol. 134, p. 110117). Elsevier BV. https://doi.org/10.1016/j.lwt.2020.110117

119. Habtegebriel, H., Wawire, M., & Sila, D. (2018). The Effect of Pretreatment (Spray Drying) on the Yield and Selected Nutritional Components of Whole Camel Milk Powder. In Journal of Food Science (Vol. 83, Issue 12, pp. 2983–2991). Wiley. https://doi.org/10.1111/1750-3841.14361

120. Rasika, D. M. D., Munasinghe, M. A. D. D., Vidanarachchi, J. K., da Cruz, A. G., Ajlouni, S., & Ranadheera, C. S. (2020). Probiotics and prebiotics in non-bovine milk. In Advances in Food and Nutrition Research (pp. 339–384). Elsevier. https://doi.org/10.1016/bs.afnr.2020.06.008

121. Abou-Soliman, N. H. I., Sakr, S. S., & Awad, S. (2017). Physico-chemical, microstructural and rheological properties of camel-milk yogurt as enhanced by microbial transglutaminase. In Journal of Food Science and Technology (Vol. 54, Issue 6, pp. 1616–1627). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-017-2593-9

122. Ali, A. H., Abu-Jdayil, B., Al Nabulsi, A., Osaili, T., Liu, S.-Q., Kamal-Eldin, A., & Ayyash, M. (2023). Fermented camel milk influenced by soy extract: Apparent viscosity, viscoelastic properties, thixotropic behavior, and biological activities. In Journal of Dairy Science (Vol. 106, Issue 10, pp. 6671–6687). American Dairy Science Association. https://doi.org/10.3168/jds.2023-23294

123. Arslan Amin, H. M., Inayat, S., Gulzar, N., Bhatti, J. A., Masood, S., Ayub, A., Kanwal, S., Batool, M., Ajmal, M., & Mustafa, G. (2024). Addition of transglutaminase enzyme in camel milk yoghurt to increase its sensorial aspects. In Brazilian Journal of Biology (Vol. 84). FapUNIFESP (SciELO). https://doi.org/10.1590/1519-6984.269043

124. Bhagiel, I., Mustafa, E.A., TabidiM., M., Ahmed, M. E., & Pha, D. (2015). Comparison Between The Physiochemical Attributes of Yogurt Processed From Camel Milk And That Processed From Cow Milk And The Effect of Storage Period on Ph And Acidity. In World Journal Of Pharmacy And Pharmaceutical Sciences (Vol. 4, Issue 8, pp.1530–1540). Atom and Cell Publishers.

125. Hashim, I. B., Khalil, A. H., & Habib, H. (2009). Quality and acceptability of a set-type yogurt made from camel milk. In Journal of Dairy Science (Vol. 92, Issue 3, pp. 857–862). American Dairy Science Association. https://doi.org/10.3168/jds.2008-1408

126. Konuspayeva, G., & Faye, B. (2004). A better knowledge of milk quality parameters: A preliminary step for improving the camel milk market opportunity in a transition economy–The case of Kazakhstan. Saving the Camel and Peoples' Livelihoods Building a Multi-Stakeholder Platform for the Conservation of the Camel in Rajasthan. In International Conference, (pp. 28–36).

127. Berhe, T., Seifu, E., & Kurtu, M. Y. (2013). Physicochemical properties of butter made from camel milk. In International Dairy Journal (Vol. 31, Issue 2, pp. 51–54). Elsevier BV. https://doi.org/10.1016/j.idairyj.2013.02.008

128. Seifu, E. (2023). Camel milk products: innovations, limitations and opportunities. In Food Production, Processing and Nutrition (Vol. 5, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1186/s43014-023-00130-7

129. Mourad, K., & Nour-Eddine, K. (2006). Physicochemical and microbiological study of a traditional butter made from camel milk in the Sahara (Algeria): isolation and identification of lactic acid bacteria and yeasts. In Grasas y Aceites (Vol. 57, Issue 2). Editorial CSIC. https://doi.org/10.3989/gya.2006.v57.i2.37

130. Berhe, T., Seifu, E., & Kurtu, M. Y. (2013). Physicochemical properties of butter made from camel milk. In International Dairy Journal (Vol. 31, Issue 2, pp. 51–54). Elsevier BV. https://doi.org/10.1016/j.idairyj.2013.02.008

131. Hajian, N., Salami, M., Mohammadian, M., Moghadam, M., & Emam-Djomeh, Z. (2020). Production of Low-Fat Camel Milk Functional Ice creams Fortified with Camel Milk Casein and its Antioxidant Hydrolysates [JB]. Applied Food Biotechnology, 7(2). https://doi.org/10.22037/afb.v7i2.27779

132. Soni, V., & Goyal, M. (2013). Potential of using camel milk for ice cream making. In Journal of Camel Practice and Research (Vol. 20, Issue 2, pp. 271–275). Camel Publishing House.

133. Jafarpour, A. (2017). Feasibility of manufacture and investigation of physicochemical properties of camel milk – based ice cream. In Journal of Scientific Agriculture (Vol. 1, p. 300). Update Publishing House. https://doi.org/10.25081/jsa.2017.v1.838

134. Khosravi-Darani, K., Jahadi, M., Abbasi, H., Asgari, M., & Tarlak, F. (2022). Production of chocolate probiotic dessert based on camel milk using Lactocaseibacillus casei. In Carpathian Journal of Food Science and Technology (Vol. 14, Issue 2, pp. 189–206). Technical University of Cluj Napoca. https://doi.org/10.34302/crpjfst/2022.14.2.16

135. Brezovečki, A. (2015). Camel milk and milk products. In Mljekarstvo (pp. 81–90). Croatian Dairy Union. https://doi.org/10.15567/mljekarstvo.2015.0202

136. Zibaee, S., Hosseini, S. M. al-reza, Yousefi, M., Taghipour, A., Kiani, M. A., & Noras, M. R. (2015). Nutritional and Therapeutic Characteristics of Camel Milk in Children: A Systematic Review. In Electronic physician (Vol. 7, Issue 7, pp. 1523–1528). Knowledge Kingdom Publishing. https://doi.org/10.19082/1523

137. The Astana Times. Camel Breeding Emerges in Kazakhstan's Karagandy Region. 17th June, 2023. Retrieved from: https://astanatimes.com/2023/06/camel-breeding-emerges-in-kazakhstans-karagandy-region/.

138. Sfera.fm news. A camel milk powder plant was opened in Kazakhstan. 5th of August, 2022. Retrieved from: https://sfera.fm/news/v-kazakhstane-otkrylsya-zavod-po-proizvodstvu-verblyuzhego-moloka.

139. Advertisement on Dastarkhan24.kz. Retrieved from: https://dastarkhan24.kz/product/shubat_daulet_beket_0_0_5_l/.

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